

there have been—between 1805 and 1864,

$$\text{Horizontal intensity} = T = 1.79183 - 0.000048119 \{t - 59.930\}^2;$$

between 1806 and 1863,

$$\text{Inclination} = i = 66^\circ 26'.09 + 0.018931 \{t - 110.543\}^2;$$

and between 1731 and 1864,

$$\text{West declination} = d = 18^\circ 8'.68 - 0.070652 \{t - 1.899\}^2;$$

all results being meant to be just for the date  $1800 + t$  in years of the Gregorian epoch.

N.B. It seems not unworthy of remark, that no evidence of the existence of a *third term* in the expression for any one of the three phenomena results from the above-mentioned observations; and this, though partly due to the inevitable imperfections of the observations, makes it highly probable that a man's lifetime, and even a century is but a very small part of the secular period of terrestrial magnetism.

II. "On the Action of Chlorine upon Methyl." By C. SCHOR-LEMMER, Assistant in the Laboratory of Owens College, Manchester. Communicated by Professor Roscoe, F.R.S. Received April 5, 1864.

In a paper published in the Journal of the Chemical Society, New Ser. vol. i. p. 425, I pointed out the great interest which attached to the study of the lower terms of hydrocarbons, known by the name of the "alcohol radicals," inasmuch as the question of the chemical constitution of these bodies requires to be more definitely settled.

Having been aided in these researches by a grant from the Council, I beg to lay before the Royal Society the results of an investigation on the action of chlorine upon methyl, which are as unexpected as they are decisive.

Equal volumes of chlorine and of methyl were exposed in strong well-corked bottles, holding from two to three litres, to diffused daylight in the open air at a temperature of about  $5^\circ \text{C}$ . The methyl was prepared according to Kolbe's method, by electrolysis of a concentrated solution of acetate of potassium, and carefully purified by washing with a solution of caustic potash and concentrated sulphuric acid. The colour of the chlorine disappeared rather quickly; colourless oily drops condensed on the sides of the bottles, and collected after some time on the bottom as a mobile liquid, the greater part of which volatilized again when the bottles were brought into a warm room. Hence it appears that by the action of one volume of chlorine upon one of methyl, substitution-products are formed, consisting chiefly of a volatile liquid, the boiling-point of which lies between  $5^\circ$  and  $15^\circ \text{C}$ . In order to collect these products, the bottles were heated till all the liquid had volatilized, and then opened, with the mouth downwards, under a hot concentrated solution of common salt, to which some caustic soda was added in order to quicken the absorption of

the hydrochloric acid, of which half the volume of gas contained in the bottles consisted. The bottles were then taken out of the liquid, placed in an upright position, and the mouth provided with a doubly perforated cork, into one opening of which a siphon fitted. Through this siphon a hot concentrated solution of common salt slowly ran in, whilst the gas thus displaced escaped by a bent tube and was condensed in a small tube receiver, surrounded by a mixture of ice and salt. The liquid thus obtained was left for some hours in contact with a piece of solid caustic potash, in order to remove moisture and the last traces of hydrochloric acid. Subjected to distillation, the liquid began to boil at  $11^{\circ}\text{C}.$ , and the boiling-point rose slowly to  $30^{\circ}\text{C}.$ , at which temperature two-thirds of the liquid had come over. On continuing the fractional distillation for some time longer, the distillate yielded a few grammes of a colourless mobile liquid, boiling between  $11^{\circ}$  and  $13^{\circ}\text{C}.$ , which, as the following analysis and vapour-density determinations prove, is chloride of ethyl,  $\text{C}_2\text{H}_5\text{Cl}$ . The boiling-point of the liquid agrees with that of this compound, and it possesses the strong peculiar smell and the property of burning with a white, luminous, green-bordered flame, characteristic of the chloride of ethyl.

#### I. Analysis :—

(1) 0.4245 grm. of the substance gave 0.5670 grm. of carbonic acid and 0.3025 of water.

(2) 0.1810 grm. of the substance gave 0.3855 grm. of chloride of silver and 0.0165 grm. of metallic silver.

Calculated for the formula $\text{C}_2\text{H}_5\text{Cl}$ .			Found.
2C	24	37.21	36.43
5H	5	7.75	7.92
Cl	35.5	55.04	55.63
	64.5	100.00	99.98

#### II. Determination of the vapour-density according to Gay-Lussac's method :—

Weight of substance employed . . . . .	0.0893 grm.
Temperature of air . . . . .	$8^{\circ}\text{C}.$
Height of barometer . . . . .	739 millims.
(1) Temperature of vapour . . . . .	$50^{\circ}\text{C}.$
Volume of vapour . . . . .	46.2 cub. centims.
Difference of level . . . . .	140.5 millims.
Vapour-density calculated from these numbers . . . .	2.245.
(2) Temperature of vapour . . . . .	$70^{\circ}\text{C}.$
Volume of vapour . . . . .	48.2 cub. centims.
Difference of level . . . . .	130.0 millims.
Vapour-density calculated . . . .	2.244.
(3) Temperature of vapour . . . . .	$80^{\circ}\text{C}.$
Volume of vapour . . . . .	49.45 cub. centims.
Difference of level . . . . .	125.0 millims.

which numbers give the vapour-density 2·235, whilst the theoretical vapour-density of chloride of ethyl is 2·233.

The boiling-point of the residue left after the first distillation rose quickly up to 60° C., whilst nearly the whole distilled over between this temperature and 70° C. By a few more fractional distillations of this latter portion, monochlorinated chloride of ethyl,  $C_2H_4Cl_2$ , boiling between 62° and 65° C., was isolated.

0·1270 grm. of this compound gave 0·3530 grm. of chloride of silver and 0·0095 grm. of metallic silver, which corresponds to 71·43 per cent. of chlorine, whilst the formula requires 71·71 per cent.

Eight litres of methyl yielded about 8 grammes of the mixed chlorides, or only about one-third of the theoretical quantity of chloride of ethyl which should have been obtained. This is easily explained by the volatilization of the liquid, and its solution in large quantities of water, as well as by the formation of higher substitution-products, in consequence of which a considerable quantity of methyl is left uncombined.

From these results it appears that the lowest term of the series of alcohol radicals behaves with chlorine exactly in the same manner as I have shown in the paper above referred to is the case with its homologues ethyl-amyl,  $C_7H_{16}$  (which gives chloride of heptyl,  $C_7H_{15}Cl$ ), and amyl,  $C_{10}H_{22}$  (from which chloride of decetyl,  $C_{10}H_{21}Cl$ , is obtained). If an excess of chlorine is avoided, the principal products consist of the chlorides of monatomic radicals containing the same number of atoms of carbon as the original hydrocarbon contained, whilst at the same time chlorine substitution-products of these chlorides are formed in smaller quantities.

As there is no reason why those terms of the series which are placed between  $C_2H_6$ ,  $C_7H_{16}$ ,  $C_{10}H_{22}$  should show a different deportment, it becomes obvious that, beginning with marsh-gas,  $CH_4$ , the lowest term in the series  $C_nH_{2n+2}$ , the most simple of all hydrocarbons, and one which can easily be obtained from its elements, we are now not only in a position to prepare all the members of this series, but likewise to build up by simple synthesis the series of mono-, di-, and polyatomic alcohols, acids, compound ammonias, ethers, &c. &c. of which each of the marsh-gas hydrocarbons forms the starting-point.

III. "On the Calculus of Symbols (Fifth Memoir), with Applications to Linear Partial Differential Equations, and the Calculus of Functions." By W. H. L. RUSSELL, Esq., A.B. Communicated by Professor STOKES, Sec. R.S. Received April 7, 1864.

In applying the calculus of symbols to partial differential equations, we find an extensive class with coefficients involving the independent variables which may in fact, like differential equations with constant coefficients, be